REMARKS/ARGUMENTS

Claims 1-7, 12, 13, 16, 17, 19, and 25 have been resubmitted. Claims 1-4, 6, 7, 12, 13, 16, 17, 19, and 25 have been amended. Claims 8-11, 14, 15, 18, and 20-24 have been canceled. New Claims 26-50 have been added.

The Examiner objected to Claim 23. The Examiner rejected Claims 17-19 and 21-24 under 35 U.S.C. Section 112, second paragraph as being indefinite. The Examiner also rejected Claims 1-2, 4-5, 7-8, 10, 12, 14, 17, and 20-24 under 35 U.S.C. Section 102(b) as being anticipated by Petzoldt *et al.* The Examiner also rejected Claims 1-5, 7-10, 12, and 20-25 under 35 U.S.C. Section 103(a) as being unpatentable over International Application WO 98/54531. The Examiner also rejected Claims 3, 9, 16, and 19 under 35 U.S.C. Section 103(a) as being unpatentable over Petzoldt *et al.* The Examiner also rejected Claims 6, 11, and 13 under 35 U.S.C. Section 103(a) as being unpatentable over Petzoldt *et al.* and WO 98/54531 in view of Marder, Arnold (Arnold R. Marder "*Effects of Surface Treatments on Material Performance: Deposition Surface Treatments*," ASM Handbook, Vol. 20, 1997, pp. 1-18).

Examiner Interview

A telephonic Examiner Interview was conducted on October 2, 2003. Various differences between the invention and prior art processes were discussed. The Examiner indicated that claims drawn to a two-step process for forming the protective coating (i.e., i) formation of an alumina layer, and ii) formation of a titanium aluminide layer), after deposition of the aluminum conversion layer, may be patentable over the cited prior art.

Amendments to the specification

Paragraph [035] has been amended to add the sentence: “The aluminum conversion layer may be deposited on the titanium-based substrate at a temperature of less than about 450° C.”

Support for this amendment may be found in the original claims (e.g., Claim 6).

Paragraph [041] has been amended to change “lower” to “higher.”

Support for this amendment may be found at page 11, lines 13-17, and within paragraph [041] itself.

No new matter has been added.

Support for amendments to the claims

Support for the amendment of Claim 2 can be found, for example, at page 6, line 20 of the specification.

Support for the amendment of Claim 7 can be found, for example, at page 10, lines 14-17 of the specification and Figure 6.

Support for the amendment of Claim 25 can be found, for example, at page 4, lines 17-20 of the specification.

Support for new claims

Support for new Claim 26 can be found, for example, at page 12, lines 4-6 of the specification.

Support for new Claim 27 can be found, for example, at page 7, lines 17-18 of the specification.

Support for new Claim 29 can be found, for example, at page 4, lines 9-20 of the specification.

Support for new Claim 30 can be found, for example, at page 6, lines 22-26, and page 10, lines 10-17 of the specification.

Support for new Claim 31 and 32 can be found, for example, at page 10, lines 14-16 of the specification.

Support for new Claim 33 can be found, for example, at page 9, lines 11-13 of the specification.

Support for new Claim 34 can be found, for example, at page 6, lines 22-24 of the specification.

Support for new Claim 36 can be found, for example, at page 10, lines 9-17 of the specification.

Support for new Claim 37 can be found, for example, at page 13, lines 13-15 of the specification.

Support for new Claim 38 can be found, for example, at page 9, lines 11-14 of the specification.

Support for new Claims 39-41 can be found, for example, at page 7, lines 7-14 of the specification.

Support for new Claim 42 can be found, for example, at page 7, lines 12-14 of the specification.

Support for new Claim 44 can be found, for example, at page 10, lines 14-17, page 12, lines 4-6, page 7, lines 17-18 of the specification and Figure 6.

Support for new Claim 47 can be found, for example, at page 6, lines 10-13, and original Claim 25 of the specification.

Support for new Claim 48 can be found, for example, at page 7, lines 17-18, page 12, lines 4-6, and page 10, lines 14-17 of the specification.

Support for new Claim 49 can be found, for example, at page 9, lines 14-21 of the specification.

Support for new Claim 50 can be found, for example, at page 4, lines 9-20 of the specification.

Claim Objections

The Examiner objected to Claim 23 because the claim did not end with a period. Claim 23 has been canceled.

Claim rejections – 35 U.S.C. section 112

The Examiner rejected Claims 17-19 and 21-24 under 35 U.S.C. Section 112, second paragraph as being indefinite. In Claim 17 the antecedent basis of the phrase “a protective coating was unclear”.

Claim 17 has been amended to delete the phrase "a protective coating". Claim 19 as amended depends directly from Claim 17.

Therefore, the Examiner's rejection of Claims 17 and 19 under 35 U.S.C. Section 112, second paragraph are rendered moot.

Claims 18 and 21-24 have been canceled.

Petzoldt *et al.*

Petzoldt *et al.* (U.S. 5,300,159) teaches a method for manufacturing tools from titanium, in which aluminum is deposited on a titanium tooling insert by ion vapor deposition (a line of sight deposition technique), and the coated tooling insert is heated to 1200° to 1700° F (649° to 927° C) for 30 minutes to 3 hours to form a titanium aluminide. The ion vapor deposition of Petzoldt *et al.* involves application of a highly negative electrostatic potential to the substrate, and electrostatic deposition of aluminum on the substrate. The highly negative electrostatic potential applied to the substrate establishes a glowing ionic discharge of inert gas around the substrate which cleans the substrate surface (column 2, lines 44-47).

In contrast, the instant invention claims a method for coating a titanium-based substrate or surface, in which aluminum deposited on a substrate surface reacts in two ways: 1. oxidation of a portion of the deposited aluminum to form an alumina surface layer, and 2. reaction of a further portion of the deposited aluminum with Ti in the substrate to form a titanium aluminide, especially the phase $TiAl_3$.

Both of reactions 1. and 2. are dependent on an appropriate, controlled temperature regime – if the temperature is too high, the deposited Al will quickly

diffuse into the substrate and react with Ti before a desired alumina layer can be formed. That is to say, if the deposition temperature and heat treatment are not carefully controlled, an alumina layer may not be formed due to the absence of surface aluminum on the substrate.

Further, if the temperature is too high, the titanium aluminide phase tends to be Ti_3Al, which is undesirable as compared with $TiAl_3$. Moreover, reactions 1. and 2. may occur at distinctly different temperatures. For example, oxidation of aluminum (reaction 1.) may be promoted at a relatively low temperature of about 400° C, while formation of $TiAl_3$ may be promoted at a higher temperature of about 700° C.

Applicant has also disclosed that a controlled temperature regime in which the temperature is increased, and subsequently decreased, at a defined rate per unit time may be used to provide both a layer of alumina and a titanium aluminide layer comprising $TiAl_3$, which layers together form an oxidative protective coating for Ti-based substrates. Applicant has also found that careful control of the temperature at which Al diffuses into the substrate can provide increased strength and fatigue life of coated components.

In contrast to the instant invention, Petzoldt *et al.* does not disclose heating at a controlled or defined rate, nor promotion of reactions 1. and 2. by the use of two different temperatures, nor the formation of an alumina surface layer. In fact, Petzoldt *et al.* teaches away from Applicant's invention by disclosing heating the substrate and deposited Al layer to a temperature of 1200° to 1700° F. Such temperatures do not promote, nor allow, formation of a surface alumina layer, and do not promote formation of a $TiAl_3$ titanium aluminide phase. Furthermore, the uncontrolled cooling from such temperatures of Petzoldt *et al.* may promote cracking of the titanium aluminide coating on the T-based substrate. In this regard, Applicant notes that cracking

of a titanium aluminide layer will destroy the effectiveness of an oxidation protective coating on titanium.

Still further, in the instant invention, the temperature at which Al is deposited on the titanium-based substrate is defined. Deposition of Al on the titanium-based substrate at an inappropriate temperature is associated with a number of drawbacks. In particular, deposition of the aluminum at too high a temperature prevents the formation of the surface alumina layer, because the aluminum diffuses into the titanium substrate during the deposition step, and there is no aluminum remaining at the surface to oxidize to alumina. In contrast to the instant application, Petzoldt *et al.* does not disclose an appropriate temperature at which aluminum is deposited on the titanium-based substrate.

The instant application claims a method involving cleaning of a titanium-based surface, using a cleaning solution, such as a solution of KOH, prior to deposition of Al.

In contrast to the instant invention, Petzoldt *et al.* does not disclose use of a cleaning solution to clean a titanium-based surface. Instead Petzoldt *et al.* teaches away from the invention by describing cleaning the substrate surface with a glowing ionic discharge of inert gas.

Applicant submits that Petzoldt *et al.* does not anticipate, nor render obvious, the amended and new claims presented herein.

<u>Raybould *et al.*, (WO 98/54531)</u>

Raybould *et al.* (WO 98/54531) teaches a titanium-based metal heat exchanger and a method of manufacture, in which aluminum is deposited on a titanium substrate, and the coated substrate is heated under vacuum to about

1200° F (649° C), whereby titanium aluminide and a surface layer of aluminum oxide (i.e., alumina (Al_2O_3)) are formed.

In contrast to the instant invention, WO 98/54531 does not disclose the use of two different temperatures for the promotion of reactions 1. and 2. as described hereinabove, i.e., 1. oxidation of a portion of the deposited aluminum to form an alumina surface layer; and 2. reaction of a further portion of the deposited aluminum with Ti in the substrate to form a titanium aluminide, especially the phase $TiAl_3$. In particular, in accordance with the instant invention, formation of an alumina layer (reaction 1.) is favored by a relatively low temperature (for example, about 400° C), while diffusion of Al into the Ti-based substrate and formation of $TiAl_3$ (reaction 2.) is favored at a higher temperature (for example, about 700° C). As noted hereinabove, reactions 1. and 2., which lead to the formation of the oxidation protective coating of the instant invention, are highly temperature dependent.

Applicant discloses a temperature regime, for formation of an oxidation protective coating, in which the temperature is increased at a rate of about 25° to 100° C per hour, and in which cooling is controlled at a rate of about 15° to 60° C per hour.

In contrast to the instant invention, WO 98/54531 discloses a temperature regime in which heating from 1000° to 1200° F is at the rate of about 200° F per hour, and in which cooling from 1200° to 1000° F is also at the rate of about 200° F per hour.

As noted hereinabove, in the instant invention the temperature at which Al is deposited on the titanium-based substrate is defined. Deposition of Al on the titanium-based substrate at an inappropriate temperature is associated with a number of drawbacks, such as excessive diffusion of aluminum into the

substrate. In contrast to the instant application, WO 98/54531 does not disclose an appropriate temperature at which Al is deposited on the titanium-based substrate.

Applicant submits that WO 98/54531 does not anticipate nor render obvious the amended and new claims presented herein.

<u>Petzoldt *et al.* and WO 98/54531 in view of Marder, Arnold R.</u>

The Examiner asserted that Marder, Arnold (ASM Handbook, Vol. 20, 1997, pp. 1-18) teaches the temperature of deposition for PVD processes.

Marder, Arnold describes effects of surface treatment on material performance, wherein Table 15 (page 13) compares various PVD process characteristics. Applicant notes that most of these processes are line of sight techniques, or are presented in the context of simply depositing a coating, and therefore are not relevant to the instant invention which involves non-line of sight deposition of a material (Al) which then undergoes two separate, highly temperature dependent reactions after deposition.

Neither Petzoldt *et al.*, WO 98/54531, nor Marder, Arnold, alone or in combination, teaches how to carefully control the coating conditions, temperatures, heating and cooling rates, and coating thickness to provide a titanium aluminide protective coating resulting in no, or minimal, decrease in fatigue life and strength, and in which cracking of the coating is prevented. Applicant submits that Petzoldt *et al.*, WO 98/54531, and Marder, Arnold, alone or in combination, fail to teach or suggest the specific combination recited in the amended and new claims as presented herein.

Allowable subject matter

The Examiner stated that Claims 15 and 18 would be allowable if rewritten to include all of the limitations of their respective base claim and any intervening claims.

Claims 12 and 17 have been amended to include all of the limitations of Claims 15 and 18, respectively, and any intervening claims.

CONCLUSION

Applicant submits that the claims are now in condition for allowance.

Reconsideration and withdrawal of the Office Action with respect to Claims 1-25 is requested.

In the event the examiner wishes to discuss any aspect of this response, please contact the attorney at the telephone number identified below.

Respectfully submitted,

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on 10/23/03

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